

# A Review of the Current Research and Development Status of Recombinant Bamboo UHPC at Home and Abroad

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## Abstract

Combining recombinant bamboo with UHPC to form composite beams has significant advantages. The lightweight characteristics of recombinant bamboo can reduce the weight of the structure and lower the cost of foundation engineering; The high strength and durability of UHPC can enhance the load-bearing capacity and service life of the structure. This combination structure fully utilizes the complementary advantages of the two materials, providing a new direction for innovative development of building structures. However, in practical engineering applications, the flexural performance of recombinant bamboo UHPC composite beams has become a key factor restricting their promotion and application.

## Keywords

Bridge Engineering; Reconstituted Bamboo; UHPC; Development.

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## 1. Introduction

Bridges, as key nodes and hubs in transportation networks, play a crucial role in road systems. However, traditional bridge construction materials mainly include cement, concrete products, and metal materials. The greenhouse effect, water pollution, and radioactive material pollution generated during the manufacturing process have gradually become bottlenecks and obstacles to China's sustainable development strategy. With the continuous promotion of major national strategies such as "carbon neutrality" and "carbon peak", China's bridge industry is actively seeking more environmentally friendly, efficient, and high-performance building materials and structural systems. Traditional building materials face many challenges in terms of resource consumption and environmental impact, and there is an urgent need to propose new materials and innovative structural forms to meet the strict requirements of modern architecture for safety, functionality, and environmental protection.

## 2. Development Status

### 2.1 Reconstituted Bamboo

Recombinant bamboo, as an emerging green building material, has received widespread attention both domestically and internationally in recent years. It uses bamboo as raw material and overcomes some of the defects of natural bamboo through a series of processing techniques, demonstrating good application prospects. At present, scholars at home and abroad have conducted extensive research on the mechanical properties of recombinant bamboo and achieved many results.

In terms of static mechanics, domestic and foreign researchers have mainly conducted relevant research on the flexural strength, compressive strength, and elastic modulus of recombinant bamboo:

(1) Flexural strength

Fadlelmola et al. [1] studied the experimental performance and design methods of lightweight bamboo concrete sandwich panels under bending loads. Research has shown that bamboo can significantly enhance the performance of aerated concrete, forming a high stiffness and lightweight sandwich panel suitable for low-cost bridge structures or non structural components.

Fang et al. [2] studied the mechanical properties of GFRP bamboo wood sandwich beams and analyzed their flexural strength through experiments and modeling. The results indicate that the bamboo concrete beam has the advantages of lightweight and high strength, and its bearing capacity and stiffness are significantly improved. The experimental data is highly consistent with the predictions of the analytical model, verifying the accuracy of the model.

Dong et al. [3] studied the bending properties of bamboo wood composite materials (CLTB) and developed two types of CLTB samples by evaluating the rolling shear characteristics of two types of bamboo and one type of bamboo plywood. The dynamic and three-point bending test results of CLTB and traditional spruce pine fir (SPF) CLT samples were compared, and it was found that bamboo (especially RB (F) -4.5 group) had significantly better rolling shear modulus and strength than bamboo plywood and SPF wood. The CLTB samples exhibit higher bending stiffness and bearing capacity, with the main failure mode being bottom layer tensile failure rather than transverse rolling shear failure, verifying the potential application of bamboo in CLT.

## (2) Compressive strength

Su Jingwen et al. [4] conducted axial compressive tests on recombinant bamboo specimens using physical experimental methods to investigate the differences in their mechanical properties. The research results indicate that its main forms of failure can be divided into two categories: one is strength failure caused by the top or bottom of the column being crushed; Another type is instability and failure caused by excessive lateral deformation, resulting in fiber breakage on the mid span tensile side. And based on this, a formula for axial compression was derived and proposed, which has a high degree of agreement with experimental results.

Li Haitao et al. [5] conducted axial compression tests on 40 recombinant bamboo columns with different aspect ratios, combined with finite element simulation, to systematically study the effect of aspect ratio ( $\lambda=20-100$ ) on the mechanical properties of the specimens. Research has shown that as the aspect ratio increases, the failure mode of the specimen gradually shifts from material crushing to elastic buckling; The load strain relationship exhibits a transition from brittle failure to ductile failure. Through theoretical analysis, it was found that the bearing capacity of short columns ( $\lambda \leq 30$ ) conforms to Johnson's parabolic formula, while the modified Perry Robertson formula is applicable for medium long columns ( $30 < \lambda \leq 70$ ), and the predicted results of Euler's theory are closer for long columns ( $\lambda > 70$ ).

Su Xiangyu et al. [6] conducted axial compression tests on three different types of columns of recombinant bamboo, and analyzed their different cross-sections through experiments.

## 2.2 Development and Research Status of Recombinant Bamboo Concrete Composite Beams

Recombinant bamboo concrete composite beams, as a new type of structural component, have received widespread attention in the field of civil engineering both domestically and internationally in recent years. It combines the excellent performance of recombinant bamboo with the characteristics of low-carbon and environmental protection, demonstrating outstanding mechanical properties and good application prospects. Meanwhile, compared to traditional bamboo wood structures, recombinant bamboo concrete composite components have higher bending stiffness and load-bearing capacity, as well as good overall fire resistance and durability [7-8]. Scholars both domestically and internationally have conducted extensive research on the recombination of bamboo concrete composite beams.

Song Xiaodong et al. [9] conducted pioneering research on prestressed reconstituted bamboo concrete composite slabs, and three sets of specimens using U-shaped shear connectors exhibited typical interfacial shear failure characteristics in mid span single point loading tests. The experimental results

show that when the deflection exceeds a certain degree, significant shear deformation occurs at the connection interface, leading to the peeling of the concrete protective layer and the development of diagonal cracks; As the load continues to increase, the connecting components eventually yield, and the composite structure reaches the ultimate bearing state. Based on the analysis of the failure mechanism, the researchers proposed three improvement measures: (1) increasing the thickness of the concrete slab to enhance the section stiffness; (2) Welding transverse steel bars between U-shaped components to enhance bonding performance; (3) Using large-diameter screws to improve shear bearing capacity.

The systematic experiments conducted by Wang et al. [10-11] confirmed that there is a negative correlation between the spacing of steel plate connectors and the stiffness of composite beams. In addition, this study quantified for the first time the advantages of recombinant bamboo in composite structures - compared to traditional wood concrete beams, the ultimate bearing capacity of BCC beams increased by 31%.

Wang et al. [12] compared and analyzed the effects of diameter and construction process (cast-in-place/prefabricated) on BCC beam connections through 8 sets of pin connections. Data shows that as the spacing between pins increases, their bending capacity will significantly decrease.

The comparative experiment conducted by Wei et al. [13] improved the design parameter database. Among the six sets of specimens, there are five types of reinforcement schemes and one set of benchmark beams. The test results show that as the diameter increases, the shear strength is greatly improved, resulting in more excellent shear performance and stability.

Mondal et al. [14] studied the load and resistance coefficient design of bamboo reinforced concrete beams, determined the key variables affecting beam performance through experiments and finite element analysis, and calibrated the partial safety factors of bamboo using Monte Carlo simulation, providing design references for sustainable infrastructure construction.

Liu et al. [15] conducted shear tests on the adhesive joints of reconstituted bamboo concrete beams and established a computational model based on the experimental results. The experimental results showed that the adhesive mechanism between reconstituted bamboo and concrete interface exhibited excellent performance.

Zhong et al. [16] studied a newly designed bamboo woven plywood composite beam (RBSC) that combines bamboo and reinforcement elements to meet the requirements of large-span structural beams. Through comparative experiments, its bending performance was evaluated, and it was found that the reinforcing element can form a stable composite section with bamboo. Its bearing capacity and bending stiffness are significantly improved, and it is closely related to the steel bar diameter and bamboo bundle heat treatment. A simplified mechanical model was proposed, and the predicted results were in good agreement with the experiments.

Yu Hong [17] conducted a systematic experimental and numerical analysis study on the mechanical properties of screw connections in bamboo plywood concrete composite structures. Through parametric experiments, the influence of factors such as screw diameter, burial depth, and concrete strength on the working performance of shear keys was mainly investigated. Based on regression analysis of experimental data, a shear bearing capacity prediction model and stiffness calculation expression considering multi parameter coupling effects were established.

Wu Wenqing [18] proposed a new type of prestressed laminated bamboo bridge deck structure, which forms a composite stress system by vertically arranging bamboo slabs and tensioning prestressed tendons. A combination of experimental and numerical simulation methods was used to study the overall continuous and longitudinal seam structures. The results indicate that the overall continuous construction has better mechanical properties, and finite element analysis verifies the reliability of the structure. This study provides new ideas for the application of bamboo in bridge engineering.

Yu et al. [19] studied the flexural performance of a new type of bamboo woven plywood concrete composite board. The compatibility between bamboo woven plywood and concrete was examined

through three-point bending tests, and the flexural performance of the composite board was analyzed through four point bending tests and uniformly distributed load bending tests. Research has found that the flexural bearing capacity and flexural stiffness of composite panels are significantly improved, and the integrity of the intermediate layer concrete is crucial for overall performance. A method for predicting the flexural stiffness of composite panels based on conversion sections and classical laminate theory has been proposed, and the calculated results are in good agreement with experimental data.

YAN et al. [20] studied the flexural performance of reinforced bamboo concrete composite beams, and explored the effects of different reinforcement ratios, concrete strength, and other factors on the flexural performance of composite beams through a combination of experimental and theoretical analysis. Research has found that increasing the reinforcement ratio and concrete strength appropriately can significantly improve the bearing capacity and deformation performance of composite beams. In addition, a new theoretical calculation model has been proposed, which can accurately predict the bending performance of composite beams and provide a theoretical basis for related engineering designs. The research results are of great significance for promoting the use of environmentally friendly building materials.

### 3. Conclusion

Although numerous achievements have been made in the research of recombinant bamboo concrete composite beams both domestically and internationally, there is still a significant gap in the related research of recombinant bamboo UHPC composite beams, such as the adaptability of design theory of recombinant bamboo UHPC composite beams in complex environments and special working conditions, accurate prediction methods for long-term performance, further optimization of construction technology, and improvement of standardization system. Therefore, it is urgent to conduct research on the mechanical and bending properties of recombinant bamboo UHPC composite beams.

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